OCEANUS

VOLUME XVII, SPRING 1973

IT'S A WHAT . . . ?

(See Inside Back Cover)

NOTE TO OUR READERS: Due to the death of Jan Hahn, founding editor of *Oceanus,* Volume Sixteen contained only three issues, the last being that of December, 1972. Volume Seventeen, of which this is the first issue, is being published on an interim basis while plans for future growth of the magazine are under study.

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OCEANUS™

Volume XVII, Spring 1973
THE WOODS HOLE OCEANOGRAPHIC INSTITUTION
Woods Hole, Massachusetts

TO OUR READERS

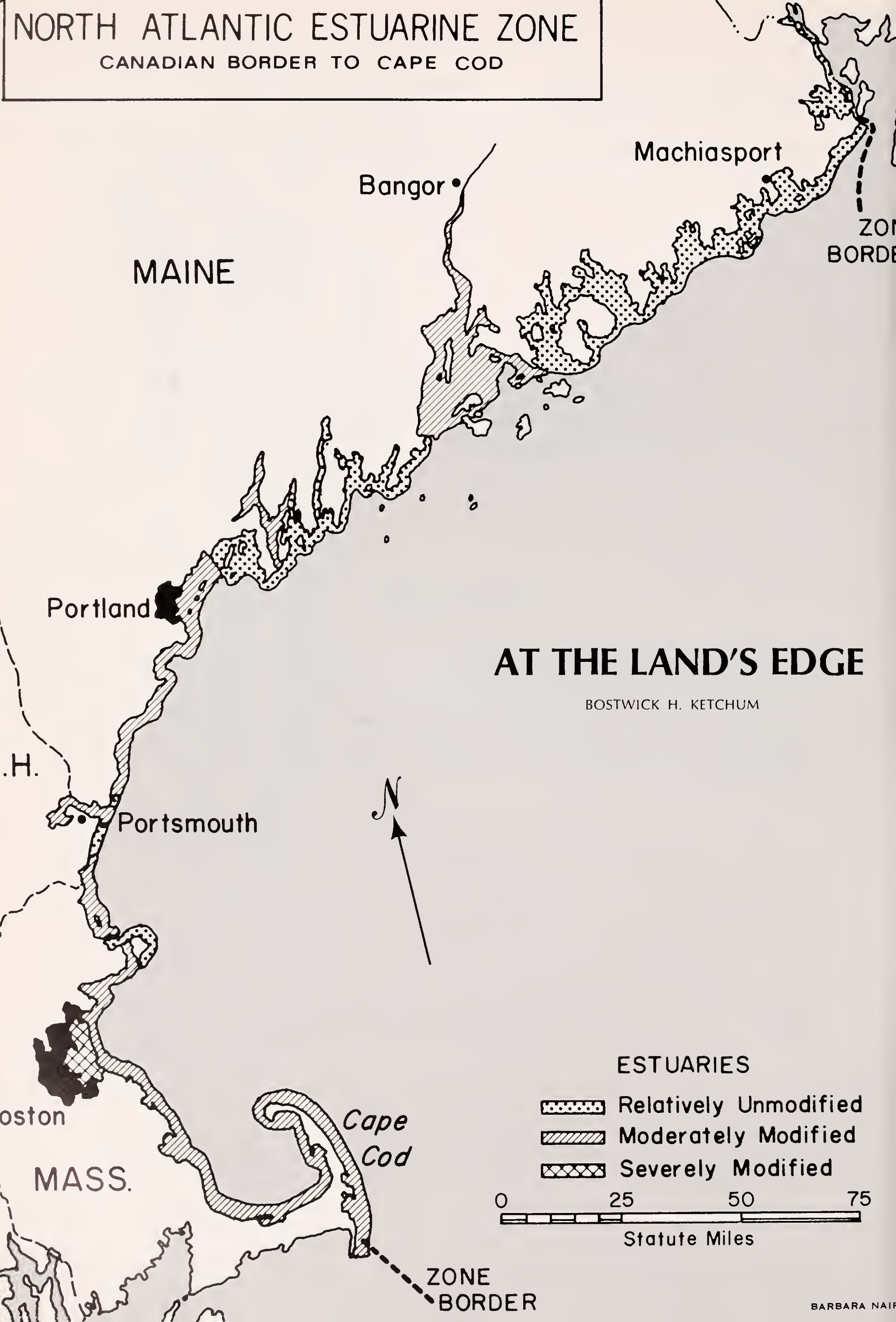
Oceanus is twenty-one. For two decades it has reported on the growth of marine research and the role of the Institution in that growth. The pace of change has been unprecedented—new hardware, new ships to carry it, new buildings, and the justification for all of it, new findings to enrich the sciences of the sea. Yet the novel never seemed to overwhelm the traditional in these pages when Jan Hahn put them together. The magazine may have attained its majority and acquired a new editor, but that balance will remain unaltered.

There are some opportunities for further development of *Oceanus*, however, and this is a good time to evaluate them. What kind of readership should we try to attract over the next decade? Should the magazine appear four times a year or six times? Should it shift to a subscription basis for non-Associates? Should it increase its coverage of marine affairs at the international and national level? Should it devote more space to the interaction of marine science and marine policy? We have been asking these questions of a relatively small group of scientists and magazine professionals. It is time to ask you, the six thousand or so individuals around the world who receive *Oceanus*. Your comments, long or short, will help us—probably more than you realize—to chart the course.

William H. MacLeish
Editor

AT THE LAND'S EDGE

BOSTWICK H. KETCHUM



" 'Coastal Zone' means the Coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in proximity to the shorelines of the several coastal states, and includes transitional and intertidal areas, salt marshes, wetlands and beaches."

— U.S. Coastal Zone Management Act of 1972.

THIS issue of *Oceanus* explores certain aspects of an environment as complex and delicate as it is important to mankind—the regions of the world where land meets sea and, perhaps more importantly, where people meet sea. In the United States alone, more than 50% of the population lives in counties bordering on seacoasts or the Great Lakes, and demographers predict the percentage will rise in coming decades. Most of the world's major cities are located where there is ready access to salt water.

Ever increasing numbers of people visit seashores for recreation—swimming, sailing, fishing, and the aesthetic satisfaction of a sunrise or sunset reflected on a wide expanse of water. Boating and other water-related recreation is one of the fastest growing industries in this country. An estimated $2,000,000,000 were spent for these purposes in 1970, and the figure is expected to increase to $5,500,000,000 by 1975. Oil and gas from offshore wells (see page 11) now account for more revenues worldwide than does fishing, and these fuels are bound to flow more freely in the United States and elsewhere given the climate of the "energy crisis". Commercial fisheries (see p. 25) now yield about 60 million tons of seafood annually, a vital source of animal protein for half the global population. In the United States, where our consumption of seafood is small in comparison to that of the Far East, the use of fishmeal as feed has dramatically increased the production of poultry.

The demands that man places upon the coastal environment have increased, and some uses are not compatible with others. Therein lies the fundamental problem of management. Coastal zone management presents many problems which are different in kind and in complexity from those of land use management. On land one can easily identify and fix the boundaries of a national park, natural preserve or agricultural area. There is an extensive legal precedent for the control and use of terrestrial resources, but there is no such precedent for marine resources. The aquatic part of the coastal zone contains no fixed boundaries. Activities in one place may affect the resources of another whose residents have had no voice in the activity nor any benefit from it.

Not all uses to which man puts the coastal zone are competitive. Commercial and sport fisheries can coexist, even though each group may accuse the other of depleting the stocks upon which their harvest depends. Yet many activities do move on collision courses, particularly those which change the character of the marine environment. For example, filling a marsh may be of great benefit to a developer and his clients; to the extent the fill decreases the breeding population of marine species, it can deprive many people of food and a source of recreation. Uncontrolled pollution of a harbor, marsh, or estuary (see page 7) is waste disposal at its cheapest and thus a financial saving for the polluters, but, again, may deplete many of the recreational and food resources once available to all. The offshore exploitation, transportation and refining of petroleum to meet energy demands have produced widespread contamination which may have a global effect on the resources of the open sea and the coast.

How can man learn to manage the coastal zone wisely so that environmental quality and desirable amenities are maintained without throttling our civilization and economic development? Answers are not easy to come by, and the decisions they lead to are difficult to make and to

Spartina grass and fiddler crab claw in Sippewissett Marsh near Woods Hole

implement. Yet the question is becoming a central one. In resort areas, residents are intensely jealous of coastal zone amenities, and numerous instances exist where housing developments have been more rigorously controlled, wetlands preserved, and indiscriminate industrial development and waste disposal prohibited. Many of our coastal states already have established or are in process of developing guidelines for coastal management. Last October, Congress passed the Coastal Zone Management Act of 1972, assigning to the Secretary of Commerce responsibility for the federal management of the coastal zone program. Appropriation of funds was authorized for grants to the coastal states to assist them in: a) developing coastal zone management programs; b) underwriting the costs of state management of their programs; and c) acquiring estuarine sanctuaries. Authorization of funds for the federal administration of the program was also included. No funds for these purposes were in the President's FY 1974 budget, and none have been appropriated. The National Oceanic and Atmospheric Administration has established an office of costal zone management by rebudgeting limited funds from other programs, but these are too modest to implement the provisions of the Act.

In June of 1972, the Critical Problems of the Coastal Zone Workshop was held in Woods Hole. The results of the deliberations of this workshop were published in October, 1972, simultaneously with the passage of the Coastal Zone Management Act.* Workshop participants examined the complexities of man's use of the coastal zones and evaluated three alternative strategies governing these activities:

1. In the past we have followed the *multiple-use* concept for the coastal zone without clearly recognizing the degree and geographical extent of conflict between some uses and others. Waste disposal, urban housing, shipping, and recreational boating would seem to be compatible uses. Yet increasing pollution eventually will interfere with recreation and the sensibilities of urban householders. In brief, the marine environment could cope with the multiple-use approach when residential and industrial pressures on the coastal zone were low. Burgeoning populations and technological developments have destroyed this recovery potential in some areas and dangerously threaten it in others. Yet technology, particularly that applied to waste treatment, can alleviate the problems of multiple use. So can management policies that identify relationships among uses and recognize the constraints they impose on each other. With effective regulation, for example, swimming, boating, and fishing can coexist with many forms of transportation without serious conflict.

2. Some parts of the coastal zone environment clearly should be set aside for *exclusive use*. Although parts of the zone are in a degraded state at present, even larger areas are still in satisfactory condition. Some of these relatively unmodified regions should be preserved to retain the essential characteristics of the coastal zone. Limited recreational activities should be permitted here, as they are in our National Parks. In other areas, the mere presence of man threatens the integrity of the environment and should be severely limited. The survival of essential genetic stocks and the perpetuation of complex natural systems could be assured by the establishment of such coastal zone wilderness areas. At the other

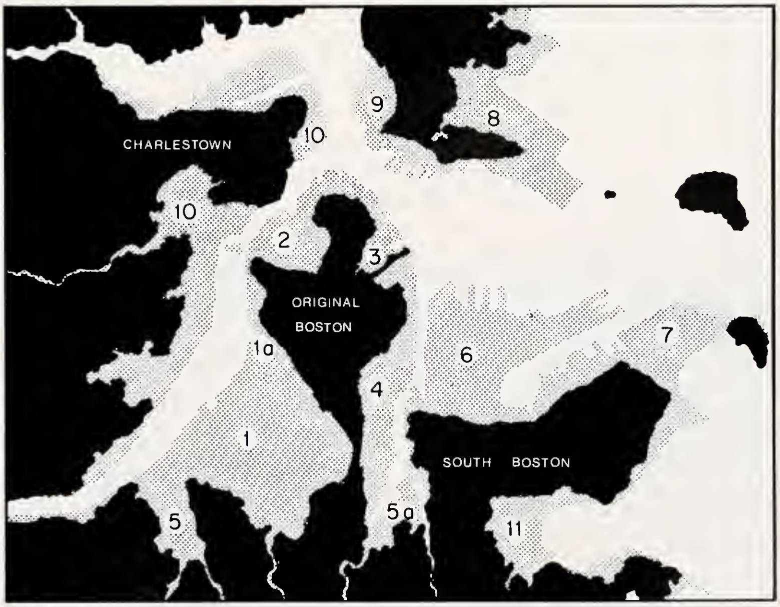
*The workshop was co-sponsored by The Institute of Ecology and the Woods Hole Oceanographic Institution and supported by grants from the National Science Foundation (RANN) and the Rockefeller Foundation. The resultant publication, "The Waters Edge: Critical Problems of the Coastal Zone", edited by B. H. Ketchum, was published by the MIT Press.

extreme of the exclusive-use scale, parts of the coastal zone could be designated as waste disposal areas. If increased understanding of the natural system allows us to predict that the complete destruction of one area will not be unacceptably harmful to other areas, it may be to our advantage to allocate specific zones for waste disposal, relinquishing the use of other potential resources in those zones.

3. *Displaceable uses* are those which could be excluded from the coastal zone without detriment because they do not depend upon coastal zone resources. Many industrial and other activities occupy the coastal zone for historical reasons and not because they must be there. Moving those already well established on the coast is unrealistic. Serious consideration must be given, however, to future decisions involving coastal location of activities whose presence will interfere with other more desirable functions. The decisions as to what are and what are not acceptable activities in the coastal zone will be most difficult to make, but they will have to be made. The Coastal Zone Management Act of 1972 requires, *inter alia,* that the states should develop "broad guidelines on priority of uses in particular areas, including specifically those uses of lowest priority."

The Woods Hole Workshop also found that after generations of neglect the coastal zone is beset with legal problems which must be resolved before any program of management can be effective. For example, jurisdictional authority in the coastal zone is divided. On the land side, state law and sovereignty dominate, along with associated police powers for the regulation of public health, safety and general welfare. Zoning authority in most states is delegated to the county or local municipal governments. The federal government typically exercises little authority inland, but a great deal on and in the water. Navigation comes under federal jurisdiction, as does construction in navigable waters. Water quality legislation provides for federally approved state water quality guidelines and serves as an additional basis for federal jurisdiction. Thus, there is a fundamental discontinuity of jurisdiction at the water's edge, with the primary influence of local decisions on one side of the line and the direct and substantial jurisdiction of federal and state governments on the other. The difficulty is that natural processes and the patterns of man's use cross this land and water boundary freely. Further, the lateral geographic boundaries of local and even state governmental units do not correspond with the natural boundaries of coastal features, and

BOSTON
LAND FILLS
(SINCE 1775)
(Numbers show
sequence of fill)



JEFFREY ZWINAKIS

thus do not meet the needs of effective coastal zone management.

Upon completion of its deliberations, the Workshop adopted a number of recommendations, many of which will be put into effect when the Coastal Zone Management Act of 1972 is finally implemented. The suggestions included the following:

1. Development of a National Coastal Zone Policy by the federal government in cooperation with the states. The Policy should focus management responsibility at the state level, with the active participation of local governments, under federal policies that provide grants and set guidelines for creative and effective programs.

2. Establishment by the National Academies of Sciences and Engineering of a multidisciplinary task force to aid the federal government in designing the national management program.

3. Development of legal institutions and procedures dealing with new coastal land and water use accommodations; alternative means of regulating coastal development other than the taking of private property; and increased access of individuals, groups and governmental units to administrative and judicial proceedings.

4. Establishment of Coastal Zone Centers to develop and coordinate natural science, social science, and legal research and to provide relevant information to government agencies and the public.

5. Creation of a national system of Coastal Area Preserves for the permanent protection of the basic genetic stocks of plants and animals and the essential components of their environments which together constitute ecosystems.

Even when the coastal zone management legislation is implemented, its accomplishments will be minimal in the absence of public support. Citizen's awareness of the issues involved, of the importance and complexity of the problems, is essential if there is to be public participation in management decisions to insure that they are both realistic and effective.

To those of us who have devoted our life to oceanography, the gradual deterioration of coastal zone resources is evident. Everyone who loves the seashore and the oceans should feel dedicated to the preservation of the coastal zone and the restoration of coastal zone qualities where they have been infringed upon by man's uncontrolled activities. The development of ecological conscience to provide reassessment of man's activities and institutions is timely. Man must begin to regard himself as a component in a beautiffully balanced system rather than as a conqueror of the system. We should adopt a "sea ethic" comparable to the "land ethic" proposed by Aldo Leopold in the late 1940's. Our greatest wealth is stored in the inherent harmony of nature, and we cannot continue to insult this system without suffering a loss, regardless of the short-term gains.

DR. BOSTWICK H. KETCHUM, an Associate Director of the Woods Hole Oceanographic Institution, is a biological oceanographer concerned with coastal processes and marine pollution problems.

EITH VON DER HEYDT

Drainage ditch in Barnstable Marsh, north shore of Cape Cod JOHN TEAL

THE LIVING FILTER

JOHN M. TEAL — IVAN VALIELA

SINCE salt marshes have long been known as valuable seafood producers, wildlife refuges and coastal fishery nursery areas, it might seem that further research would only paint in details of a picture already nearly finished. In reality, however, much about the functions of these productive areas is completely unknown or poorly understood. This is especially true of the effects of pollution from ever increasing levels of human activity along our coastlines. Our present ability to manage and protect salt marshes is inadequate.

Three years ago, we began studies in experimental ecosystem ecology of salt marshes. We knew from earlier work that there is a certain amount of marsh production not consumed on the marsh but exported to the estuaries. However, previous attempts to measure export had been largely failures. Answers remained elusive, even to the obvious question of precisely why the marsh grass *Spartina* grows luxuriantly on tidal creek banks while it fares much less well a few feet away.

Experiments with whole ecosystems require the participation of many investigators over considerable periods of time. A salt marsh is a relatively simple system with few important plants and animal inhabitants; its most important organisms are perennial grasses. Yet it has taken the authors, aided by about a dozen graduate students and assistants, some three years to arrive at a body of significant findings. This is due to the length of time required for marsh grasses to reach maximal growth after an experimental perturbation and also to the many kinds of experiments which are necessary.

In our general experiment we fertilize circles of marsh ten meters in diameter at the heads of small drainage ditches. Each circle is separated from the others by higher marsh, flooded only at the highest tides. This keeps the treatments separate and allows us to compare the results from one plot with those from its neighbors. Fertilization increases the production on the plots and permits us to determine what limits marsh plant production, i.e., which nutrients stimulate growth and which do not. At the same time, we are able to measure how increased plant growth stimulates production by animals dependent on plant food.

The complete fertilizer used in the experiment is sterilized sewage sludge obtainable in most garden shops. Use of secondary sewage effluent might better have reproduced the type of sewage pollution commonly found in salt marshes. Effluent, however, is difficult to apply. It is also low in the most damaging of waste substances—heavy metals, PCB's, pesticides and hydrocarbons—most of which are trapped in sewage sludge. By adding commercially prepared sludge to the marsh, we are artificially creating the worst sort of sewage pollution, the kinds resulting from the direct addition of toxic materials (either through sludge dumping or malfunctioning of sewage treatment plants) or from long-term exposure to trace amounts of toxic substances in effluents.

Only by undertaking such experiments on a small scale in living salt marshes can we expect to measure the maximum amounts of pollution that salt marshes can withstand without disruption. The alternative is to wait for and study pollution that occurs by accident. These fortuitous experiments can be useful, but in general it is difficult to obtain appropriate controls for comparison. In our studies one set of controls remains in its natural state while another set of plots is fertilized with pure nutrients. All, including the sludge-fed experimental plots, are subject to the same vicissitudes of weather and the same cycles of tides. All began with similar populations of animals and plants. Thus the effects of the nutrients added with the sludge can be separated from the effects of the noxious pollutants and the effects of weather separated from the effects of nutrients. In addition, there is no prolonged wait for just the right accident to occur before we can start work. This, plus the opportunity to set up adequate controls, we believe make up for whatever small damage may be caused by the treatments.

Nitrogen has been found to limit plant growth on marshes. When more nitrogenous fertilizer is applied, growth increases until the grass becomes so tall and luxuriant that it probably uses all available sunlight and can grow no further. Application of phosphorus fertilizer does not increase grass production, and the application of the sludge fertilizer has an effect on grass production very similar to that obtained with nitrogen alone. This may not be the case for all marshes, especially new ones growing on sand, but in a marsh with fine-grained organic muds, there is an abundance of all the nutrients other than

IVAN VAL

Researchers measuring production rate of salt marsh vegetation nitrogen. These nutrients are presumably brought by tides and trapped in the mud, where they become available to the plants.

Nitrogen is also carried by tides and is probably the principal factor behind the thicker, taller growth of grasses on creek banks, those areas of the marsh most exposed to tidal water. Over most of the marsh, however, the vegetation depletes nitrogen stored in the mud by incorporating it into grass tissue. This depletion is faster than the rate at which tides replenish sediments with nitrogen, with the result that over most of the marsh the average growth of grass is lower than that in the creek banks.

A large portion of the nitrogen needed to support grass growth in situations other than those on creek banks comes indirectly from the air. Certain bacteria and bluegreen algae can fix nitrogen—that is, they are able to change nitrogen gas into chemically-bound nitrogen which can serve as a plant nutrient. This is the same process by which bacteria in root nodules of certain legumes fix nitrogen and enrich upland soils. Nitrogen fixation occurs only when the plants do not obtain enough fixed nitrogen from external sources to meet their needs. When the external supply is sufficient, fixation stops.

This is precisely what happens when we fertilize the marsh. In fact, the cut-off of nitrogen fixation is a key to the ability of salt marshes to handle sewage pollution. The nitrogen absorbed by our highly fertilized plots is not only that needed for the observed increase in production but also that needed to replace the amount previously fixed naturally.

There is evidence that the marsh also denitrifies some of the nitrogen compounds in our sewage fertilizers. Denitrification is a bacterial process that produces gaseous nitrogen from nitrate. Because of their high productivity, salt marsh muds are devoid of oxygen a few millimeters below the surface. Denitrifying bacteria can use nitrate as a substitute for oxygen, freeing the nitrogen in the process.

The result of these three processes—increased production of organic matter, reduced nitrogen fixation, and increased denitrification—is that salt marshes can remove nitrogen very effectively from polluted waters that pass through them. They act as tertiary sewage treatment systems for our coastal waters.

In our most heavily fertilized plots, we add 70g N/m² yr by fertilizing every two weeks during the growing season, which extends from May to October. Somewhat less than 15g is lost by being washed away by high tides immediately following the applications. Washout would probably be less if we were to apply the treatments more often, but the added trampling accompanying fertilization would damage the marsh. There is an indication that the grasses could use even more nitrogen, for they are still not as tall in our plots as they can grow at our latitude. In some Massachusetts marshes where tidal ranges are greater than in Sippewissett, *Spartina* in creek banks grows to about twice the height as that in our plots with the highest levels

JOHN TEAL

Root system of *Spartina* marsh grass

of fertilization. Thus, it seems likely that our marsh could remove at least 110g N/m^2 yr if evenly applied. This is roughly twice the amount applied in any of the terrestrial living filter systems that are in use or proposed for sewage processing.

We have not yet established the upper limits of the marsh's ability to clean up waters, nor do we know whether very high levels of nitrogen will actually harm the marsh. So far we have found few detrimental effects. Fiddler crabs are the only animals which have been affected. In the areas of heaviest sludge application, crab populations have been lowered by about half. The toxic material appears to be found in that fraction of the sludge which ought to contain chlorinated insecticides. The sludge contains heavy metals, but no effects from these substances have been found. *Spartina* does pick up lead, and in the course of export into deeper water may be a mechanism for transporting lead to coastal food chains. The fertilizations have also prompted some changes in the kinds of microscopic algae growing on the surface of the mud. Over all, however, the effects of our fertilizations on most of the components of the marsh have been clearly beneficial in that animal and plant production have increased with little change in the composition or appearance of the marsh.

DR. JOHN M. TEAL is a Senior Scientist in the Institution's Biology Department. His work includes research on petroleum hydrocarbons, bird migrations, and the effect of pressure on the physiology of marine animals.

DR. IVAN VALIELA is Assistant Professor of Biology at Boston University. He teaches and conducts research in the B.U. Marine Program at the Marine Biological Laboratory in Woods Hole.

Additional readings in this field include:

1. Teal, J.M. 1962. "Energy flow in the salt marsh ecosystem of Georgia"
2. John and Mildred Teal, *Life and Death of the Salt Marsh,* Atlantic-Little, Brown Books, Boston, 1969.
3. In press. Valiela, I. and J.M. Teal, "Nutrient limitation in salt-marsh vegetation".

Hay staddles—posts used for stacking marsh grass in the days of salt haying JOHN TEAL


KENNETH EKSTROM

Left to right: C. E. Oduro (Ghana Geological Survey), K. O. Emery, and A. K. Amoo (Ghana Fisheries Unit) plotting geophysical data from recordings onto maps of the ocean floor off Ghana.

OIL ON THE SHELF

K. O. EMERY

OIL that occurs in rocks (and thus is termed *petroleum*) is a product of partial decomposition of phytoplankton that grew upon the nutrient salts dissolved in water, using sunlight as an energy source for the biochemical reactions. Most of the annual crop of phytoplankton is destroyed by bacterial and chemical decomposition and by utilization as food by small and large animals that live in the water or the bottom. Only a vanishingly small percentage of the total crop of phytoplankton becomes deeply buried in the sediments; even less is converted to petroleum, and only a minor part of that can be recovered from the rocks. In fact, the total efficiency of conversion from solar energy to the combustion energy of oil and gas is less than one part in a million. It is a wonder that petroleum exists and can be found in usable quantities.

The chances of success in the search for petroleum are improved when one realizes that nearly all oil and its associated gas must be within or near the ancient, original, organic-rich source sediments. The hard, igneous rocks that have been exposed by erosion on land are barren, and few bodies of lake sediments are large enough to provide a significant amount of oil. Even most nearshore marine sediments are too coarse-grained to contain much organic material. Thick sequences of fine-grained marine sediments 20 to 200 million years old, the most common sources for oil and gas, occur at present drilling depths (to about 150 meters) only in certain special environments of the continental shelf. One of these comprises the large deltas of very old major rivers such as the Mississippi, Amazon, Plata, Congo, Niger, Nile, Po, Rhine, White, Mackenzie, Yukon, Yellow, Yangtze, Mekong, Brahmaputra, Ganges, Indus, and Euphrates. Commercial quantities of oil and gas have been found in most of these deltas; further search is justified in the remainder.

A second environment consists of closed basins such as those off southern California and in parts of the West Indies and the East Indies. Close relatives are long, narrow troughs that parallel the coast and trap sediments from the land. Present examples are the Adriatic Sea, the Gulf of California,

Recorders aboard *R/V Atlantis II* plotting the structure of the continental margin off western Africa as measured by seismic reflection method.

KENNETH EKSTROM

and the shallow discontinuous depressions along western Canada and Chile. Former troughs, now filled to the brim with sediments, lie along the entire length of East Asia, the Atlantic continental shelf of North America, off northern Brazil, and along parts of western Africa and Europe. Variants of these troughs are the long reef-protected lagoons of Australia, Florida, and parts of the Gulf of Mexico. Here, however, the same high-temperature water that causes luxuriant growth of coral and calcareous algae increases bacterial activities that destroy the organic matter in the lagoon sediments.

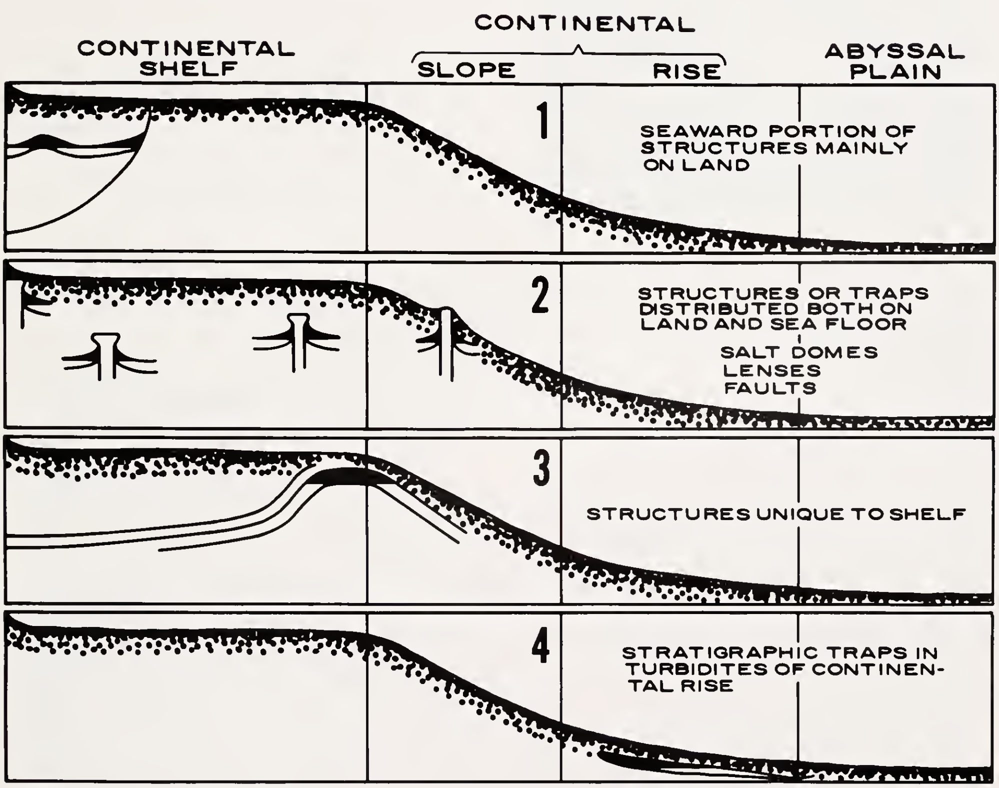
Even where adequate source sediments are present beneath the continental shelf, oil and gas in commercial concentrations do not occur unless two other structural components are present. Coarse-grained, permeable reservoir beds (usually sandstones), interleaved with the source sediments, permit the flow of oil and gas through the strata to the wells that tap them. Although shales are the chief source beds, they are nearly impervious and require the pressure of overburden and the passage of time to release their oil and gas into the interbedded sands that can be tapped by the drill. The sand beds may be deposits from long periods of floods in steep-gradient rivers that discharged at the shore, or they may have been laid down by fast-moving bottom currents.

The second additional requirement is a geological structure which serves to concentrate oil and gas from broad areas of a reservoir bed into a small area, an oil field. Many such structures occur on continental shelves in the form of folds caused by lateral compression of a region of bedded sediments; by local bending caused by penetration of salt pillars (salt domes) into overlying sediments; and by regional compaction of thick sediments over buried hills. On the inner part of some shelves, structural folds continue seaward from the adjacent land and are fairly easily found. Similarly, areas of salt domes that occur widely scattered on land may extend onto the shelves. However, the shelves also include isolated oil traps whose presence must be determined from marine geological and geophysical surveys.

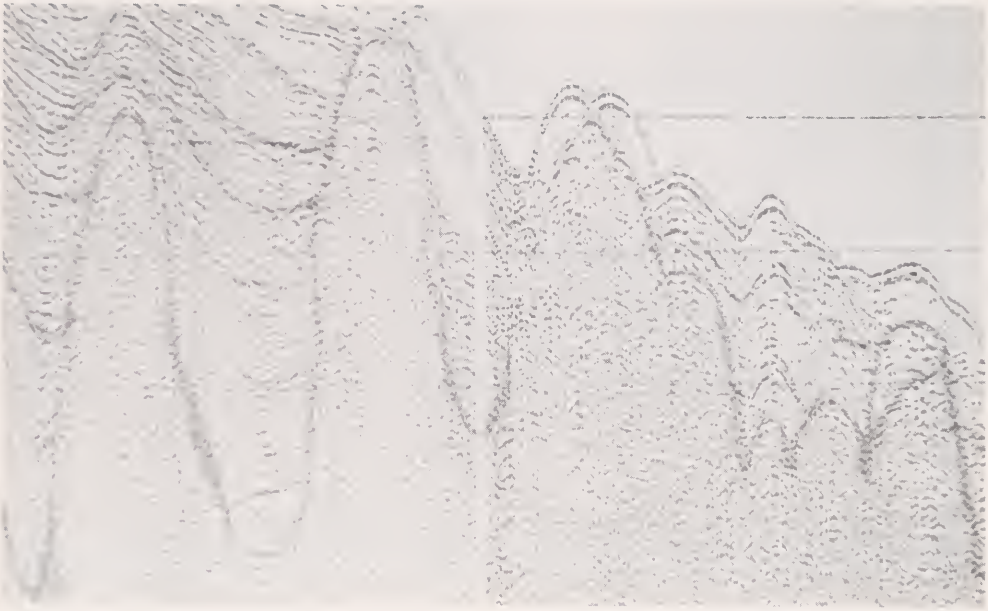
Modern methods of geophysical exploration, particularly seismic reflection methods, are capable of mapping thick sequences of fine-grained sediments (nearly transparent to sound) that may be oil source beds; interbedded sands (good acoustic reflectors) that may be reservoir beds; and many kinds of folds, faults, salt domes, and other interruptions of the strata beneath continental shelves that may contain concentrations of oil and gas. Detailed seismic surveys have been conducted by oil companies and contract service companies on many of the most promising parts of the world's continental shelves. Broader regional seismic studies have been made by oceanographic institutions and universities with the objective of learning the composition, structure, and origin of the entire continental margin (shelf, slope, and rise). Many of these studies have shown, among other scientific findings, the existence of thick sedimentary basins—regions that subsequently have been leased by the governments of adjacent countries to oil companies for detailed exploration and exploitation. Leasing is much desired by the treasuries of most coastal states. The United States, for example, has received about $7,000,000,000 for leases since 1950. Arabian countries have received far more in the way of royalties for production from both ocean-floor and land wells and undoubtedly will continue to do so. All told, the dollar value of oil and gas from the shelves of the world exceeds the dollar value of fish and other food from the whole ocean.

Two different paths are now being followed with respect to oil and gas production on the continental shelves. Over the past five years, the United States has tended to reduce its exploitation programs. All other producer countries have increased theirs. Reduced effort off the United States has been largely the result of political pressure by environmentalists anxious to preserve the quality of the beaches and coastal waters. Offshore drilling has been their major target even though only seven of 10,000 existing offshore wells have produced large spills. The three largest were two off Louisiana in 1970 (53,000 and 30,500 barrels) and one off Santa Barbara, California, in 1969 (20,000 barrels). In contrast, the wreck of the *Torrey Canyon* off England in 1967 spilled nearly 1,000,000 barrels, and the cumulative smaller annual losses of oil from tankers by washing, spillage, collision, and grounding may exceed 20,000,000 barrels.

Substitution of tanker imports for domestic offshore drilling and pipeline transport to shore probably will add greatly not only to our international trade deficit but to



Schematic diagram of structural and stratigraphic traps for oil and gas on continental shelves, slopes and rises. The oil and gas (black) float atop brine in the reservoir beds beneath impermeable shales. The sequence from top to bottom represents accumulations at progressively greater water depth and distance from shore, and this at progressively lower levels of knowledge and exploitation.



Shipboard recordings of salt domes off western Africa mapped aboard *R/V Atlantis II* during March 1973. The salt forms steep-sided pillars that have forced their way upward and have deformed overlying sediments. The scale of this recording is about 2 km vertically and 22 km horizontally.

coastal pollution as well. An almost negligible amount of oil is produced in the Mediterranean Sea, but tankers have left a good deal of tar on its beaches. Conversely, one-sixth of the world's oil comes from the offshore and coastal region of the Caribbean Sea and the Gulf of Mexico, yet, owing to pipeline transport, the beaches of this region are oil-polluted chiefly only near oil refineries and shipping points. Even pipelines are not absolutely safe, however, as several have been broken by anchors of ships in storms and oil has been released to the ocean water.

The significance of these data becomes apparent when one considers that the excess of demand over domestic supply of oil in the United States has led to imports (mostly in tankers) of 20% of annual requirements, with the prospect of an increase to 40% by 1980—all this attended by greater prospects of large spills and coastal pollution.

Although offshore oil has been produced since 1890, drilling began in earnest in 1950. Fifteen years later, offshore output accounted for about 16% of the total world production. The figure is now 20% (of 18,000,000,000 barrels) and it may reach 30% by 1980. Earliest offshore production took place mainly off Louisiana and California and in the Persian Gulf and Lake Maracaibo. During the past ten years, large new offshore fields have been established in the North Sea, off Nigeria, Gabon, Indonesia, and Australia; smaller ones are off Brazil, Chile, Spain, Norway, China, and Canada. Continuing investigations off China, India, and elsewhere can lead to new production at any time.

The major oil-producing and exporting countries have joined to force up royalties and prices for both financial and political gain. At the same time, many developing coastal nations have become entranced by the expectations—mostly exaggerated—of great wealth to be had from their continental shelves. With anticipation have come claims over wider areas of territorial seas and growing suspicion of all "outsiders" who wish to visit these areas—even of the international oceanographic expeditions that can at no cost provide the first clues to the presence of thick offshore sediments.

Fewer than one dozen nations, all technologically advanced, have the knowledge, capital, and energy to explore or exploit the shelves for oil and gas. The usual arrangement has been that of concessions or leases granted by host countries to oil companies—with little or no contribution from the host. A recent trend has been the nationalization of oil fields on land as soon as they become profitable. Will the same trend occur as regards offshore oil fields? If so, will nationalization be accepted by the companies as readily as it has been on land? Will fear of such action by host governments, coupled with further technical developments, lead toward drilling in very deep water on continental rises that now are beyond any reasonable claims of adjacent coastal nations?

At present, almost nothing is known about the oil potential of continental rises, but the volume of their sediments probably exceeds that beneath the continental shelves, and seismic studies show the presence of shales, sands, and both structural and stratigraphic traps. At this stage of knowledge, a move to the continental rise could represent as great an advance in the winning of oil and gas resources as did the move during the past few decades from the land to the continental shelf.

DR. KENNETH O. EMERY is a Senior Scientist in the Department of Geology and Geophysics at the Institution. A recent article by Dr. Emery bearing on the subjects discussed below appeared in *Science* (Vol. 178, pp. 298-301) under the title "Eastern Atlantic Continental Margin: Some Results of the 1972 Cruise of the *R/V Atlantis II*."

KENNETH EKSTROM

Above right: Assembling a 300-cu. in. air gun on deck of *Atlantis II* for use in seismic reflection profiling. *Below:* Running the air-gun lines over the side.

PATTERNS OI

Distribution of sedimentary basins (diagonal hatching) on land and the continental shelf containing thick sediments younger than 200,000,000 years, the age range of most oil- and gas-bearing strata. Note the frequency with which these basins and troughs follow the coasts of the world. Some that are now inland originally

ETROLEUM

lay along the coasts of continents that later joined to squeeze the sedimentary fill into mountains (Alps, Himalayas, Urals). The dotted pattern denotes continental rises, which may contain even more oil and gas than the shelves but are yet unexplored by drilling.

Remains of Cape Cod cedars drowned by the sea

ROBERT WORTHINGTC

LESSONS FROM THE SALT MARSH

ALFRED C. REDFIELD

THE coast of the United States from Cape Cod to Mexico is bordered by an almost continuous series of barrier beaches in the shelter of which are salt marshes fringing shallow bays. This vast stretch of marshland is a unique feature as extensive as the Great Barrier Reef of Australia. Studies of these marshes are of importance in themselves. The purpose of this article, however, is to indicate how such research has provided information on other coastal processes of broader interest.

The beaches and their enclosed marshes owe their origin to the fact that the margin of the continent is a nearly flat coastal plain and that in the recent past the surface of the sea relative to the land has been slowly rising. At the margin of the land, erosion has built beaches, and behind them sand hills have formed. As the relative sea level has increased, water has flooded in behind the sand hills, forming shallow bays fringed with salt marshland.

Salt marshes are formed by plants which can survive periods of immersion in salt water. Prominent among them is the coarse grass, *Spartina alterniflora,* locally known as thatch. It can grow down nearly to the low-water level and spreads over sand flats as they build up in shallow bays to form dense stands which in favorable situations may reach five or six feet in height.

Sand washed in by the tide and mud from tributary rivers settle among the thatch. The sod formed by the roots of the plants and the sediment produces peat. Its surface rises year after year until it reaches the level of high water, after which it builds up only as fast as sea level rises.

Because it was formed in this way, salt-marsh peat preserves objects which may have become imbedded in it at an earlier time and provides a record of conditions which existed during its formation.

The salt-marsh peat is frequently 20 feet or more in thickness. The deeper layers must have been formed when the sea level was much lower than at present. In many places near or below low water, remnants of forests which must have grown originally on dry land are preserved in the form of tree stumps still rooted in their natural position. When salt marshes are dredged, cedar logs are frequently found where swamps have been submerged by the rising sea. Cliffs which evidently were cut by sea waves now stand in places protected from substantial erosion. Such cliffs may be seen at Barnstable and near the Nauset Coast Guard Station. Other cliffs which face salt marshes extend without break in slope to substantial depths into the peat. Evidently these cliffs were cut before the formation of beaches which now protect them from the sea and have sheltered the marshes as they have grown upward with rising sea level. Such a cliff at West Barnstable descends to a depth of 18 feet below the surface of the marsh. There is a similar one near the mouth of the Herring River in Dennis.

Marshes preserve the contours of the land on which they have been deposited. By sounding the peat to the depth of hard bottom, the form of the submerged land is revealed. In the Barnstable marsh, tongues of sand extend into the marsh from Sandy Neck; the peat overlying them is much thinner than is that surrounding them. These tongues appear to be remnants of the hooks which frequently form at the end of sand spits and indicate positions at which the growth of Sandy Neck was temporarily arrested. A prominent tongue near the present end of the sand spit still rises above the marsh surface and supports a sand hill.

At the western end of the marsh, an island of sand covered with trees rises from the marsh at a distance of 200 yards from the sand hills. It is evidently the top of a

Sandy Neck and salt-marsh creek at Barnstable marsh

MARGOT BALBONI

Barnstable Marsh from Sandy Neck MARGOT BALBONI

sand hill, the base of which has been submerged by the rising sea level. It is surrounded by a fifteen-foot depth of peat formed as the sea level has risen. Sounding reveals that a chain of submerged sand hills lies buried in the peat east and west of this island. One of these is 150 yards long and rises to within two feet of the present marsh surface. Another rises a few inches above the high marsh, an elevation sufficient to alter the kinds of plants which cover its surface. The presence of these submerged sand hills is notable because it is commonly found that barrier sand spits move landward, and spread over the enclosed marsh in the course of time. This is evidenced by the emergence of marsh peat near the low-water level on the seaward side of the sand spits. At Barnstable the reverse has taken place. The marsh has spread seaward over the inner margin of the sand hills.

Salt marshes can tell us something of the history of the vegetation of the nearby upland. Tree pollen deposited year by year on the marsh is buried and preserved as the marsh builds upward. Cores of peat taken from a series of depths in the Barnstable marsh show that above the deepest peat, at a depth of 29 feet, tree pollen is that of a mixed hardwood forest of oak, beach, and pine. At the 17-foot level the predominant species of pollen change abruptly. The hardwoods disappear, and the pollen is dominated by pine and hemlock. This situation prevails until a level of about two feet below the surface is reached, above which the pollen of grasses becomes dominant. This distribution suggests that the climate was relatively dry and warm during the first years of the marsh formation, then turned moister and cooler. Hemlock is now practically absent from Cape Cod forests, though it is abundant in northern New England. The predominance of grass in pollen near the surface may be attributed to the clearing of the land by the early European settlers.

Remnants of human culture are also preserved in the marshland. Artifacts showing the presence of an Indian encampment have been exposed between high- and low-water levels by erosion of marshland on the Taunton River. Excavations of a marsh made in the course of restoring a seventeenth century iron works at Saugus have uncovered a number of weapons and implements of the period, preserved in good condition by burial in the peat. At West Barnstable old wharves facing Spring Creek and Brickyard Creek, now buried under a foot of peat, indicate that the creeks were a useful means of transportation to the local settlements before the railroad came.

The situations which have been described are all to be interpreted by the recent rise in sea level. Since the elevation of the high marsh where new peat is formed is everywhere nearly the same at any time, the age of peat recovered from increasing depths permits a time scale to be assigned to the responsible processes. The time since samples of peat were formed by grasses growing at the marsh surface may be estimated by measuring their content of radioactive carbon. It is found that along the coast of southern New England during the past 2,000 years, sea level has risen relative to the land at the average of about four inches in 100 years. Prior to that period sea level was rising about three times as fast, at an average rate of one foot in 100 years.

The oldest peat found in the Barnstable marsh was recovered from the location that yielded the pollen samples. At a depth of 29 feet, it was about 5,500 years old. At a depth of 17 feet, where the change in the character of the pollen occurred, the peat was probably 3,000 years old. The location is in what was a valley sheltered from the open sea when the marsh first developed. Along the more exposed shore where such shelter was lacking the oldest peats are about 3,500 years old and lie at a depth of 22 feet below the present high-water level. The peat at the base of the submerged cliff at West Barnstable was formed about 3,200 years ago, after Sandy Neck had developed sufficiently to protect the cliff from further erosion. Sandy Neck must have begun to form somewhat earlier than 3,500 years ago.

The sand hill which emerges from the marsh about a mile from the base of Sandy Neck and is surrounded by peat to a depth of 15 feet must have been first submerged by the rising sea about 2,900 years ago. The sand spit must have extended beyond this position before that time. About three miles from the base of the sand spit, the deepest peat in the marsh bordering Sandy Neck has an age of 2,000 years and at about five miles from the base its age is 14,000 years. Along the remaining mile of its 6-mile

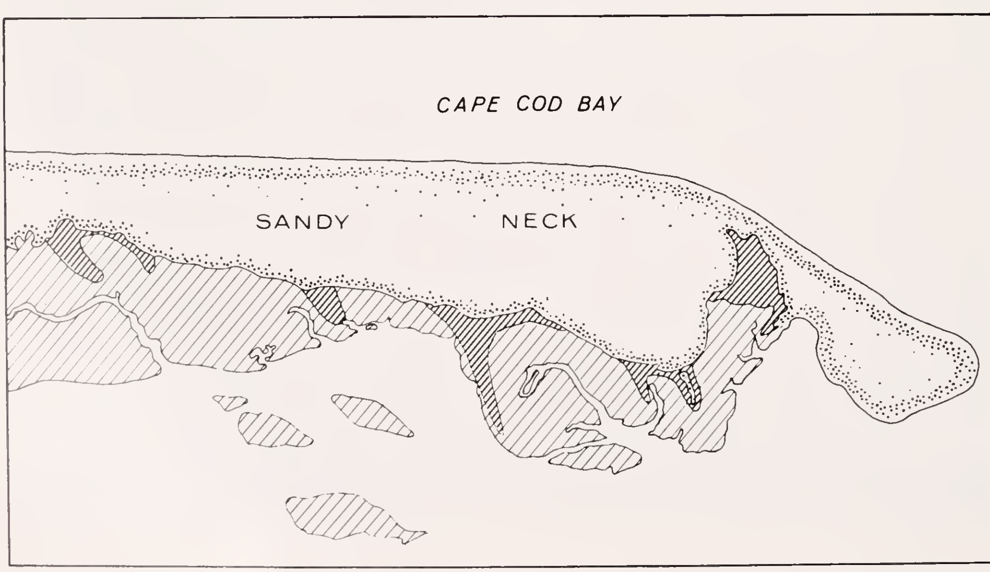
On the flats of Barnstable Marsh MARGOT BALBONI length, the peat is less than 200 years old and the marsh extends only to within half a mile of the end of the spit.

One does not know how long it took for the marsh to appear after the sand spit was formed. However, measurements give some perspective of the times required for its development. They show that Sandy Neck and its enclosed marsh are, geologically speaking, very new features which have developed within something on the order of 4,000 years.

Of more general interest is the bearing of the age and depth of salt-marsh peats on the rise of sea level and its causes. It is considered that the rise is due to two processes: the warping of the earth's crust, and an increase in the actual amount of water in the ocean resulting from the melting of the continental glaciers. The effect of a change in the amount of water in the ocean would be the same everywhere, while that due to warping would be expected to differ from place to place. In a region where the earth's crust has been stable, the rise in sea level relative to the land would be due entirely to the increase in the volume of ocean water. At other places the change due to the warping of the earth's crust would be equal to the total change observed less that occurring in the stable region.

The relation of age to depth of peats at different parts of the Atlantic Coast indicates that the rise in sea level relative to the land differs markedly in different regions. Between Cape Cod and Virginia the relative rise appears to have been about 25 feet in the past 4,000 years. On the coast of Massachusetts Bay, the change is smaller —about 14 feet in that period. Data from North Carolina, Florida, Louisiana and Bermuda indicate a change of only about 10 feet in 4,000 years. The smaller change in this southern group of positions and its wide distribution suggest that they are in a region where the earth's crust has been stable and that the rise in sea level is due to an increase in the volume of the ocean water. If so any larger change in the rise in sea level relative to the land may be attributed to an actual subsidence of the land. The subsidence would be 15 feet along the coast between Cape Cod and Virginia and four feet on the shores of Massachusetts Bay.

Another unexpected by-product of the study of marshes is a determination of the rate at which heat produced by radioactivity within the earth is escaping through its surface. When sounding the marsh on a hot summer day, is was noted that the steel sounding rod came up deliciously cool, and it appeared that the summer heat had not penetrated very far into the peat. Since the



EDNA CONEYBEAR

theory of the penetration of heat into the soil is well known, it was thought that a study of the thermal regime within the peat would throw light on whether the water in the peat is stagnant or whether its temperature is disturbed by a flow of water through the peat with the rise and fall of the tide. It turned out that heat diffuses through the peat with the changing seasons almost exactly as fast as it would if the peat were a stagnant mass of water. The seasonal change in temperature decreased rapidly with depth. The annual variation is less than 0.2°C at a depth of 15 feet where the temperature is about 10.5°C throughout the year.

The unexpected finding was that the average temperature within the peat increased at a rate of 0.09°C per meter. Heat must diffuse upward along this gradient. When the measured rate of diffusion of heat in peat is considered, the measurement of the heat flow from the earth agrees with the measurement made in bore holes on land and by probes dropped into the bottom of the deep sea in neighboring regions. The measurement can be made wherever marshes of sufficient depths occur and much more cheaply than on land or at sea.

DR. ALFRED C. REDFIELD is Senior Scientist Emeritus and former Associate Director of the Institution and Professor Emeritus of Physiology at Harvard. His interests and accomplishments in marine science are too diverse for review in this space. Aspects of this article are discussed more fully in the following papers by Dr. Redfield:

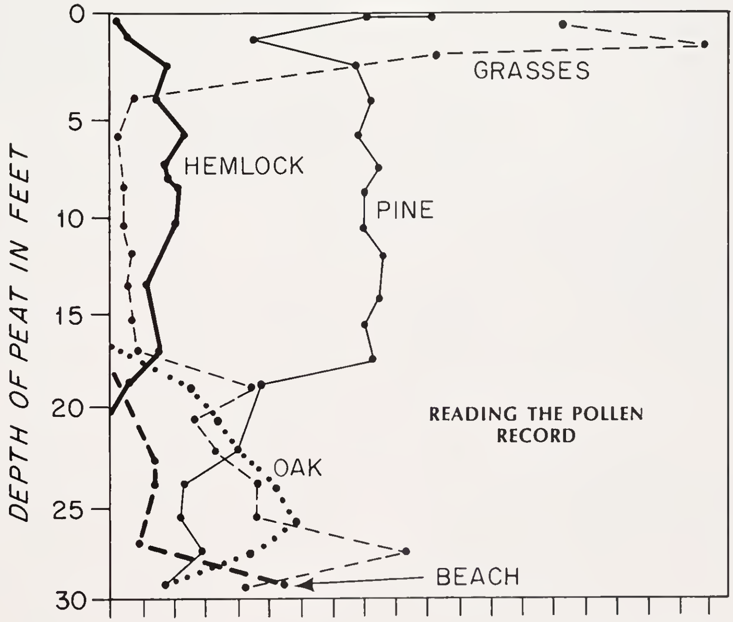
"The Ontogeny of a Salt Marsh Estuary," *Science*, 1965, Vol. 147, pp. 50-55.

"Postglacial Change in Sea Level in the Western North Atlantic Ocean," *Science*, 1967, Vol. 157, pp. 687-692.

"Development of a New England Salt Marsh," *Ecological Monographs*, 1972, Vol. 42, No. 2.

Left: Heavily hatched areas indicate tongues of sand extending under the Barnstable Marsh from Sandy Neck

Right: Distribution of pollen species indicates climate was warm and dry during first years of marsh formation, then turned moister and cooler.



MARTHA THOMSON

Small catch from a
groundfish tow off Georges Bank

A QUESTION OF EFFORT

R. HENNEMUTH

A meeting of technical fishery experts from 13 countries* was convened in Woods Hole from 26-30 March by the National Marine Fisheries Service. Many of the participants were old friends, having faced each other across meeting tables and in the bars and restaurants of European and North American cities for many years while attending meetings of the International Commission for the Northwest Atlantic Fisheries (ICNAF), a multi-lateral treaty organization for the investigation, protection and conservation of fisheries. The scientific committees of ICNAF had met before in Woods Hole in 1961. However, the problems considered in the two meetings were significantly different, and several of the countries represented at the March conference were not members of the ICNAF nor participants at the earlier meeting. Both factors reflected the immense development of fisheries over the last ten years, a basic cause of the present crisis in fishery management.

Perhaps nowhere in the world is the crisis as acute as in the Northwest Atlantic, more particularly in the waters off New England and the Middle Atlantic states. The U.S. was the only country fishing in the latter area in 1960, excepting a few Canadian vessels, and caught about 300,000 tons of finfish in some 37,000 standard trawler days of fishing. Things were serene enough in 1961 so that the scientific committee of ICNAF meeting in Woods Hole found it necessary only to consider the effects of increasing the mesh size in the trawl nets used to catch cod, haddock and redfish. There was mention of increasing fishing rate and some cautionary comments that more effective conservation measures might have to be considered in the future.

In 1971, this southern area of ICNAF was heavily fished by more than eleven countries. The finfish catch had risen three-fold to over 1,000,000 tons and the fishing effort had increased almost five-fold to about 194,000 standard trawler days. The U.S. catch and effort had decreased, however, and its share of the catch was only about 14% of the total. The sea was so jammed with the larger, long-distance fleets that at times the U.S. vessels were crowded off their traditional grounds. The decreased U.S. fishery was primarily due to the decreased supply and availability of the traditional groundfish species.

Indeed, tradition might well be one of the villains in the decline of the U.S. fisheries. Customary fishing methods, fishing grounds, and species markets were not modified to increase the competitive stance of the U.S. vis-à-vis the long distance fleets of other countries. Failure to do this led to reluctance on the part of the U.S. industry to press for regulations to control the amount of fishing, primarily because of the severe, short-term economic loss involved. However this may be, the fisheries in question are coastal, developed with shore-based processing, and very efficient relative to American economic standards. These standards do not apply to the state fisheries of eastern bloc countries, and the U.S. Government had no means of redressing the

*U.S., Canada, USSR, Denmark, Federal Republic of Germany, Spain, Portugal, France, Poland, Japan, Norway, U.K.—all members of ICNAF. German Democratic Republic was represented. Four other ICNAF members were not present—Iceland, Romania, Italy, Bulgaria.

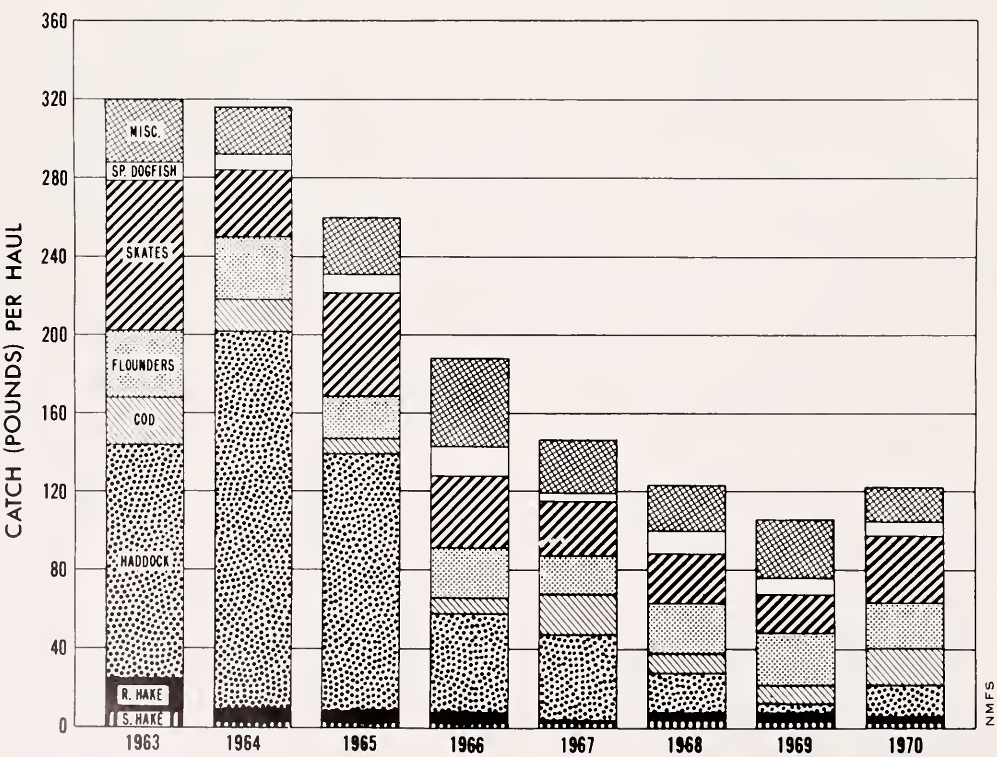
N.B. Other countries fishing in the area include Greece, Cuba, Venezuela, Mexico.

costs of conservation to the U.S. fisherman. In any case, it is certain that the rapid development of the long-distance fleets caused a severe decline in the stocks of fish upon which the U.S. was dependent and was the major factor in the decline of the U.S. fisheries.

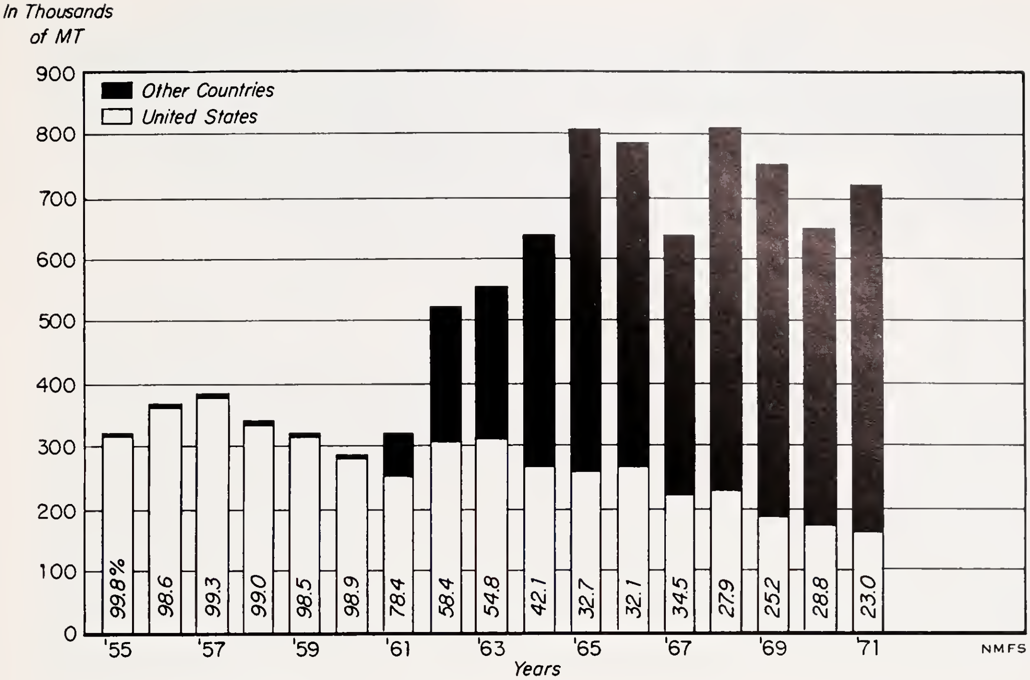
The increase of the long-distance fleet operations in the Northwest Atlantic was encouraged by the general underutilization of the fish stocks by the coastal fisheries. Many species—e.g. cod, redfish, herring, silver hake, mackerel—provided a large, seasonably concentrated biomass ideal for the operations of the large-vessel fleets. These fleets were deployed to harvest the accumulated biomass of a given species. After reducing the stock to a level where the catch rate was unacceptable, the fleets moved on to the next stock. A large fleet of scouting, "research" vessels was deployed to search out and define the best opportunities. At the start of this operation in the late fifties and early sixties, there was always another stock of fish—in another area or of a different species—which could support the fleet. In many cases, the stocks were not of concern to the coastal fishermen, and although they were apprehensive of the armadas invading "their" waters, the effect was not felt immediately in their day-to-day activities.

At this time, waters outside of the three-mile zone were international, and the resources therein considered a common property. This is still the case, except that a nine-mile zone contiguous to the three-mile limit has been reserved for U.S. fishermen. Many of the stocks of fish within 12 miles are part of common populations extending outside the limit. Fishing outside affects the abundance inside.

The initial success of the long-distance fleets led to building more, bigger, and better vessels. The expanded fleets began to find fewer and fewer areas in which the large, underexploited stocks could be found. Thus, instead of moving on, they had to stay and become more opportunistic—taking advantage, for example, of the occurrence



NMFS finfish surveys in the area of Georges Bank off Massachusetts



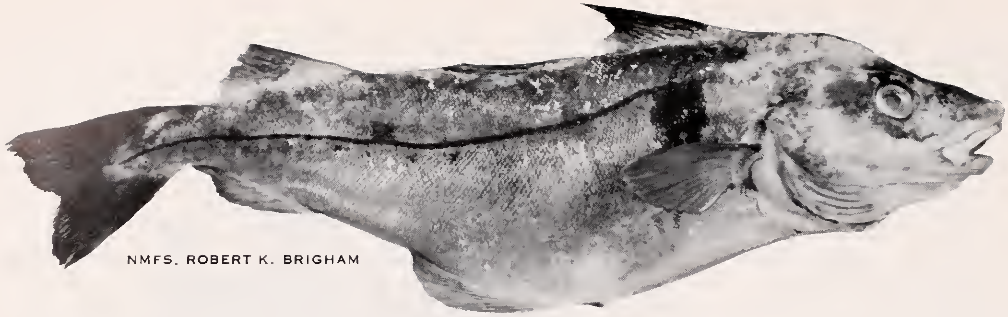
Finfish landings in ICNAF Sub-Area 5 (Gulf of Maine to Southern New England)

of a good year class (the surviving progeny of one year's spawning) in an already heavily exploited stock. In between the seasonal concentrations of species to which the effort was primarily directed, it became necessary to keep the fleet on the grounds, fishing in areas of lesser abundance for a combination of species. The kinds of fish were less important than the volume. The factory ships could process the fish not desired for food into fish meal and oil. This development led to a more direct competition with the coastal fleets, which were not able to shift gears and areas successfully.

It became more and more evident that management and control of the rate of harvest were required. In 1965, the research and statistics committee of ICNAF began warning that more and more stocks were being overfished, i.e. the population had been decreased to the point where more fishing effort would in the long run produce less fish. The stock of a particularly important species, haddock, had been reduced to the point of eliminating the fishery, and even the survival of the species was threatened.

Beginning in 1969, quotas limiting the annual take of fish were enacted for several stocks which were demonstrably overfished—haddock, yellowtail flounder, sea herring. The actions, however, were too little and too late to stem the tide of increasing exploitation, primarily for three reasons: 1) There was no legal basis for allocating quotas among nations; 2) the most severe reductions in catch required by the quotas would be made on stocks traditionally fished by the United States. Other fisheries to which excess effort could be diverted were not available; 3) as with the initial application of any concept, the proof required to demonstrate the necessity of the quotas was somewhat beyond the capability of scientists to provide until the stock reduction was so severe nobody could dispute it. The rate of development of the fisheries was just too great to keep up with in terms of scientific assessment of its effects.

There were, perhaps, other reasons: the long-distance fleets were still increasing both their catch and their effort; and other countries just joining the fisheries were interested in expanding rather than reducing their catch.



Twenty-five pound haddock caught on Georges Bank in 1961; one of the largest ever recorded from the western North Atlantic

In late 1971, after five years of discussion, ICNAF adopted a new protocol which provided for national allocation, dividing the total allowable catch into country quotas. In 1972, quotas on many of the main species stocks were adopted, with national allocation. This was the first time such multilateral agreements had been adopted by an international fishery commission.

However, in the latter half of 1972, an alarmingly large increase in foreign fishing effort was observed in the waters off New England. It was becoming apparent to U.S. scientific advisers that the total biomass of finfish in the area was being over-exploited, and that the scramble to assess effects of fishing on all the individual species was not going to provide the information necessary for proper regulation. At a special meeting of the commission held in Rome in January, 1973, the USA proposed a 31% reduction in fishing effort in this region for countries other than U.S. and Canada. The U.S. proposal represents the first attempt in a multilateral international commission to limit the fishing effort—the total biomass of fish in a given area.

The need for total effort regulation is, to some extent, related to the nature of the area concerned—an area with a variety of species which are highly intermixed. Even fisheries which are directed to a single species take a significant by-catch of other species. It is difficult, if not impossible, to regulate the catch of all the species individually at a level which will keep the stock at the desired size. The by-catch problem also makes it difficult to allocate to the U.S. fisherman a large enough share of some species to satisfy his needs; the by-catch of a given species in some cases exceeds the total allowable catch.

A number of commission members at the Rome conference raised a multitude of objections to the proposal, some of them valid criticisms and others a reflection of an unwillingness to be effectively restricted. The recent meeting in Woods Hole was convened to clarify the concepts and counter the objections so that the proposal could be considered again in a more enlightened atmosphere at the annual ICNAF meeting in Copenhagen in June. The meeting did not solve the technical problems which presently stand in the way of a solution—such as how to determine an adequate method of estimating the fishing power of the variety of fishing vessels, gear and methods of application, and of adjusting for the by-catch—but it did make quite clear the magnitude of the problems and the need to solve them if conservation of the fishery resources is to be a reality rather than a worthy objective.

The meeting was, to some extent, the culmination of ten years of frustration and failure to develop an adequate scheme of management for an international fishery by an international fishery commission. The political problems are even more difficult to solve than the technical. The solution will, perhaps, be found in a different forum.

The United Nations Law of the Sea Conference is scheduled to meet next year. This conference may well decide that the solution to fishery resource management is the formation of patrimonial seas, in which the coastal nations will control and manage the fisheries to meet the needs of coastal

R/V Riga, Russian factory base ship, on Georges Bank off the coast of Massachusetts NMFS

Sorted groundfish species including haddock, cod, and eel pout NMFS, ROBERT K. BRIGHAM fishermen first and, perhaps, share the remainder of the surplus production with other nations. The thrust in ICNAF has led to the acceptance of the need for coastal fishery preference, and even some acceptance that an overall limit to fishing is required. ICNAF has advanced further than any other regional commission. However, the recent U.S. proposal and the Woods Hole meeting indicate the same malaise is still evident. The idea is new and there are technical difficulties in administration. An actual reduction is required in total effective fishing time by the long-distance fleets. The continued development of long-distance fishing capacity by some nations using New England fisheries must be halted. There are not many undeveloped regions left in the world's oceans where effort displaced from New England and Middle Atlantic state waters can be re-deployed without adverse effects. The scientific assessment of the total finfish productivity is not at the stage of high degree of certainty. Countries are not yet willing or able to deal with these problems—at least not within the required time frame— or to develop an equitable means of sharing the catch, within the constraint of conservation requirements. The Woods Hole meeting carried the struggle one step further; it will continue in June in Copenhagen.

RICHARD C. HENNEMUTH is Deputy Director of the Northeast Fisheries Center at Woods Hole, Mass. He has worked with the Assessments Subcommittee of the International Commission for Northwest Atlantic Fisheries, whose work has led to the adoption of catch limitations and other conservation measures in the region.

Additionial readings touching on the subject of this article include:

1. "Report of Working Group on Joint Biological and Economic Assessment of Conservation Actions, Part IV." ICNAF Annual Proceedings, Vol. 17, 1966-67, p. 56.
2. "Report of the ICES/ICNAF Working Group on Cod Stocks in the North Atlantic." ICES Cooperative Research Report No. 33, February 1973, pp. 1-52.
3. In press. "Management of Sea Herring Fisheries in the Northeast Atlantic." Proceedings, FAO Technical Conference on Fishing Management and Development, Vancouver, 1972.

American fishing trawlers on Georges Bank NMFS

FREEDOM TO KNOW

Dr. Philip Handler, President of the National Academy of Sciences, is one of several distinguished authorities to point out the threat to oceanography posed by current proposals that would place much of marine research under the control of coastal states. Following are excerpts from Dr. Handler's recent remarks before Subcommittee III of the United Nations Committee on the Peaceful Uses of the Seabed and the Ocean Floor.

FRANK MEDEIROS

DAVID OWEN

The scientific community is deeply disturbed by the suggestion of some nations that scientific research at sea be subjected to the exclusive control of a coastal state, not only in the confines of its territorial sea, but also in maritime zones beyond. Presumably, one purpose of such control in these zones would be to regulate the possibility of exploitation of offshore living and non-living resources in the interest of the economic well-being of the coastal state, and to assure that foreign research vessels will not acquire unshared information previously unknown about nearby ocean areas . . .

The world has embarked on a course from which there is no turning back. Poets may yearn for simpler days, for seemingly better times. And all of us may, at times, wonder if the material benefits generated by science and technology are worth the cost. The brute fact is that even if science and technology have been important contributors to some of our current troubles, only science and technology can provide acceptable solutions. No matter what the price of industrial development, there seems little chance in this era that any country will voluntarily restrain its economic growth and no one could seriously so propose for those nations of lower per capita income. Hence, the pressing need for all possible scientific understanding for the mutual benefit of all.

Accordingly, I call on scientists of all nations to work together to allay the fears of those who have been led to mistrust the purposes of consequences of unrestricted ocean science. A year ago, the Academy which I head, exercising its traditional independence, proposed to other Academies of Science around the world that all recognize the distinction between open scientific research and what we call "limited commercial exploration."

While there may be other equally valid ways of expressing this distinction, we proposed the following:

By open research is meant that which is intended for the benefit of all mankind and is characterized by prompt availability and full publications of results. It is directed at improved understanding of the planet, not at searching the sea floor for exploitable resources. It is protection of such open scientific research which is my concern today.

Limited exploration, as we use that term, is that which is intended for the economic benefit of a limited group, as evidenced by restrictions on publication and on the availability of data and samples. [Later on in his speech, Dr. Handler returned to those definitions and pointed out that "Admittedly, there is no foolproof system for differentiating between these two proposed categories of marine activity and no set of definitions will be interpreted uniformly by all. But our community interests demand that in this small degree we risk trusting one another."]

The Academy also recommended to other Academies and today urges that international arrangements permit and encourage open research in the area of the territorial sea and we believe that the following provisos offer adequate assurance to the interests of coastal states. These provisos are that the coastal state shall:

(1) be given reasonable advance notice, a period of 60 days normally being adequate.

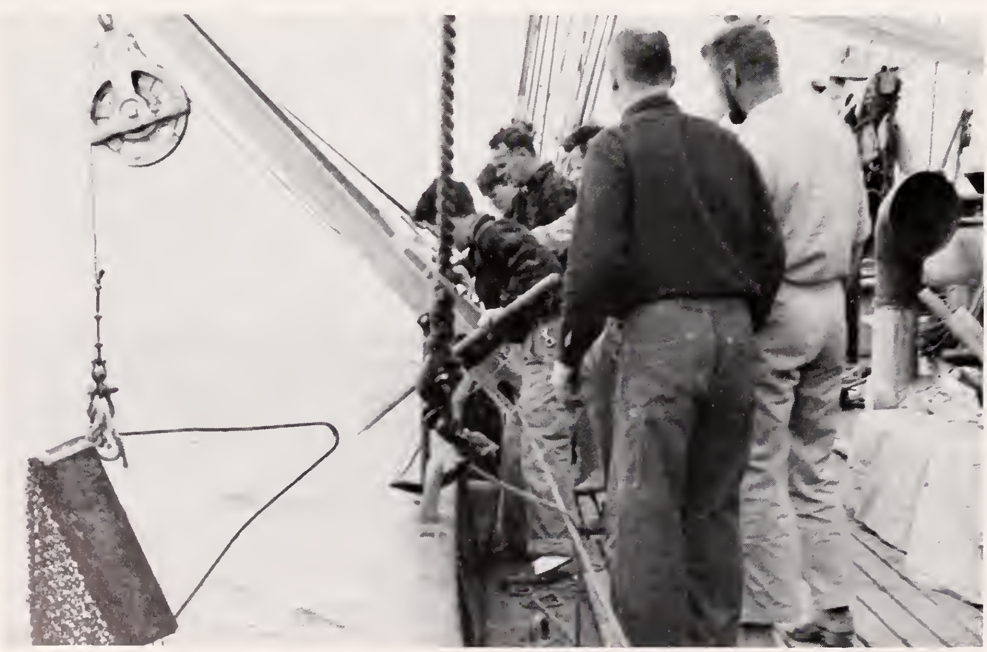
(2) have the opportunity to participate or be represented in the research and have access to all equipment, compartments and instruments aboard the research vessel.

(3) have the right to receive copies of all data on request, and the right of access, for study, to all samples which it is not feasible to duplicate.

(4) be assured that significant research results will be published in the open scientfic literature; and

(5) be assured that these scientific activities will present no hazards to the resources or uses of the sea or seabed.

We believe that basic research cannot flourish in a regulated environment and we think that it must flourish if the contribution of science to the benefit of mankind is to continue to be truly meaningful. Accordingly, we urge that the new regime which you are engaged in constructing impose no restrictions on basic research beyond the territorial seas.



DAVID OWEN

. . . IT'S A "JENNY HANIVER"!

PHOTOS BY FRANK MEDEIROS

This one comes from Central America, as does many a Jenny Haniver these days. It was given to the Institution in 1968 by Dr. Thorsten V. Kalijarvi upon his retirement as Dean of Faculty at Cape Cod Community College. Dr. Kalijarvi received it in 1960 from an assistant to General José Maria Lemus, then President of El Salvador.

Jenny is, or was, a small male skate whose carcass was cut, trussed and prodded into a prime specimen for the teratologist. She descends from a long line of hoaxes, from sea eagles to bishopfishes. Dr. E. W. Gudger, in his comprehensive "Jenny Hanivers, Dragons and Basilisks in the Old Natural History Books and in Modern Times", (*The Scientific Monthly*, June, 1934, Vol. XXXVIII, pp. 511-523) quotes one Guillaume Rondelet who, writing in 1554, refers to an account "that in 1531 a sea monster clothed like a bishop had been brought before the King of Poland. This had vehemently indicated by certain signs that it desired to be restored to the sea. Led thither, it had thrown itself into this." However, added Rondelet, "I have intentionally omitted many details which were told to me about this monster, since I deem them fables. For it is the vanity of men that about a thing marvelous enough in itself, they wish to add many things besides the truth."

And the name? Dr. Gudger refers to a suggestion that Haniver sounds like an anglicization of "Anvers", French for Antwerp — "a probable place of their origin." But Dr. Richard Backus, chairman of the Institution's Department of Biology, has learned of a more devilish explanation. Jenny Haniver, says his source, may be the best the British sailors could do with the French "génie d'enfer", the genie from hell.

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